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COOPERATIVE GROUNDWATER REPORT 6

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ILLINOIS STATE GEOLOGICAL SURVEY
Champaign, Illinois 61820

# ASSESSMENT OF A REGIONAL AQUIFER IN CENTRAL ILLINOIS

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Below 8-1/2 feet, the borings were advanced by rotary drilling, washing cuttings to the surface with water or, when necessary, with bentonite mud. Cuttings were collected at 5-foot intervals, and split-spoon samples were taken approximately every 10 feet. The sampler used is a standard 2-inch O.D. split-spoon which was driven 18 inches with a 140 pound hammer. Suitable samples were tested with a pocket penetrometer in the field.

After each boring was completed, a Logmaster downhole, geophysical logger was used to obtain self-potential, single-point resistivity and natural gamma ray logs of the boring walls. A generalized natural gamma configuration is included with each boring log in appendix 1.

After the drilling program had been completed, the samples were taken to the Geological Survey laboratories for more detailed study and testing. Selected samples of the aquifer were sieved to determine grain-size properties of the deposits. The results of these tests are reported in appendix 2. Grain-size analyses were run on selected fine-grained samples, both to characterize the nature of the materials confining the aquifer and to aid with the stratigraphic correlation of till units. The pipette method was used for this test. X-ray analyses of the clay fraction of selected samples were made as an additional tool for characterization and stratigraphic correlation of till units. The procedures used have been outlined by Killey (1980).

Carbon-14 analyses were made on two organic samples by the Geological Survey, using a benzene liquid scintillation technique.

Final maps, figures, and interpretations were made from the above types of information. Aquifer thickness and configuration were determined principally from TA borings, electrical resistivity surveys, water well logs and samples, and, to some extent, sieve data and geomorphic interpretations. Most of the bedrock topography interpretations were made from TA borings and oil and gas well logs, with significant contributions from samples and logs of water wells. The cross sections were drawn from TA borings and some water well logs and samples.

## Geology

### *Bedrock Stratigraphy*

The upper bedrock strata in the study area are Pennsylvanian in age. The uppermost bedrock formation in most of the area is the Bond Formation, which is generally less than 200 feet thick here. North of Macon, less than 100 feet of the Mattoon Formation overlies the Bond. Both of these formations are composed primarily of fine-grained materials and yield insignificant amounts of water either to wells or as recharge to other aquifers.

### *Pleistocene Stratigraphy*

Central Illinois was crossed by continental ice sheets several times during the Pleistocene. A thick succession of Pleistocene units presently covers the bedrock in the study areas (figures 7 and 8). The oldest Pleistocene units encountered in the study area are referred to in this report as till units E and D (figure 7). These units are included in the Banner Formation and are deposits from pre-Illinoian age ice sheets.

Till unit E, the oldest and deepest unit, was encountered in borings 7, 9, 12, 13 and 15. It is a brownish-gray, silty till with a textural average for eight samples of 19 percent sand, 60 percent silt and 21 percent clay (disregarding one anomalously sandy sample in TA-7). The average clay mineral assemblage for nine samples is 18 percent expandables, 49 percent illite, and 33 percent chlorite plus kaolinite. Till unit E is usually slightly darker than the overlying till unit D. Unit E does not have the pink tinge which is frequently noticeable in D, but it does have variably colored, basal inclusions of underlying shale material. Till

<table>
<tr><th colspan="3">TIME UNITS</th><th colspan="3">ROCK UNITS</th></tr>
<tr><td rowspan="10">PLEISTOCENE SERIES</td><td colspan="2">HOLOCENE STAGE</td><td colspan="2">CAHOKIA ALLUVIUM</td><td></td></tr>
<tr><td colspan="2" rowspan="2">WISCONSINAN STAGE</td><td rowspan="3">WEDRON FORMATION</td><td>PIATT TILL MEMBER</td><td rowspan="3">HENRY FORMATION</td></tr>
<tr><td>FAIRGRANGE TILL MEMBER</td></tr>
<tr><td></td><td>FARMDALIAN SUBSTAGE</td><td>ROBEIN SILT</td></tr>
<tr><td colspan="2">SANGAMONIAN STAGE</td><td rowspan="3">GLASFORD FORMATION</td><td>HAGARSTOWN MEMBER</td><td rowspan="5"></td></tr>
<tr><td colspan="2" rowspan="2">ILLINOIAN STAGE</td><td>RADNOR TILL MEMBER</td></tr>
<tr><td>VANDALIA TILL MEMBER</td></tr>
<tr><td colspan="2" rowspan="2">PRE–ILLINOIAN</td><td rowspan="2">BANNER FORMATION</td><td>TILL UNIT D</td></tr>
<tr><td>TILL UNIT E</td></tr>
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*Figure 7. Pleistocene units in the study area*

unit E is consistently lower in illite than till unit D, and on the average is higher in both of the other clay components. Texturally, till unit E is slightly less sandy than till unit D.

Correlation of till unit E with a named till outside the study areas is uncertain. There may be a relationship between till unit E and the Hegeler Till Member in east-central Illinois (Johnson et al., 1972; John P. Kempton, Illinois State Geological Survey, personal communication). However, long-distance correlation of these tills, which include basal incorporation of significant amounts of shale, may be questionable (H. D. Glass, Illinois State Geological Survey, personal communication). Stratigraphic control is inadequate in this case.

Till unit D, which was found in ten of the twenty borings, overlies till unit E and is beneath the Vandalia Till Member. In one boring, TA-14, till unit D was directly over bedrock and till unit E was absent. Frequently, a sand layer was found between the two tills. In TA-11, a thick sand occupied the entire interval between till unit D and the bedrock. In TA-10, a well-developed paleosol was sampled beneath till unit D. Unfortunately, samples between the buried soil and bedrock were too poor to allow determination of the geologic unit in this interval.

Till unit D is a pinkish, brownish-gray to grayish-brown, silty till. The pink tinge, although not always present, helps distinguish the unit from tills above and below. The average texture for seventeen samples was 29 percent sand, 53 percent silt, and 18 percent clay (two anomalous samples were deleted: one from TA-9 and one from TA-11). The average clay mineral percentages for ten unoxidized samples were 8 percent expandables, 66 percent illite, and 26 percent chlorite plus kaolinite. Till unit D has a much larger percentage of illite than till unit E. Till unit D is distinguished from the Vandalia Till Member above by a lower sand content and sometimes by a color change. Some samples are very high in calcite. Till unit D commonly contains silt and sand seams.

As with till unit E, correlation with other named till units surrounding

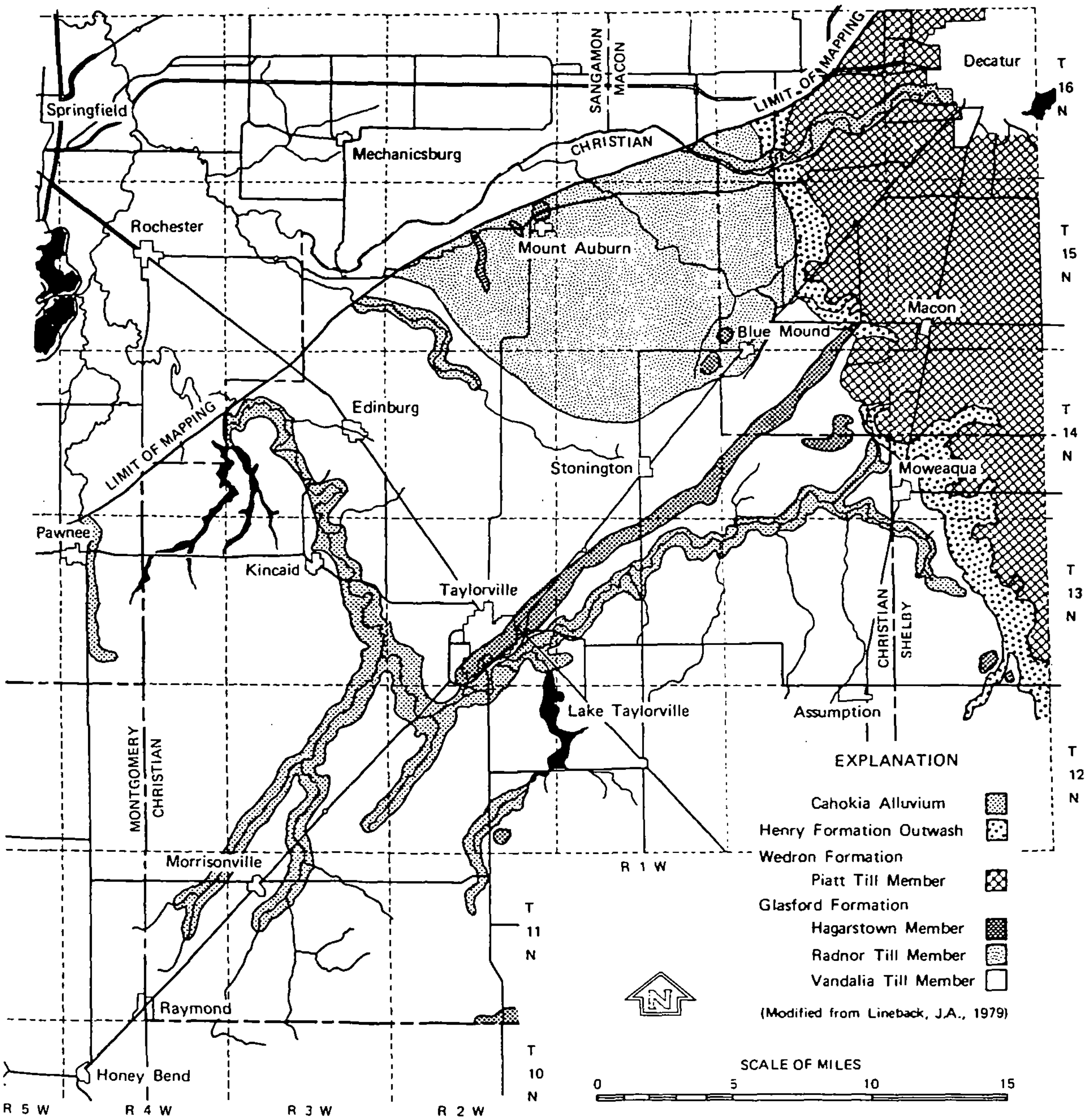


*Figure 8. Pleistocene surficial deposits*

the study area is uncertain. A possible relationship to the Hillery or Tilton Till Members in east-central Illinois is suggested (Johnson et al., 1971, 1972; John P. Kempton, Illinois State Geological Survey, personal communication).

The uppermost till of the area is correlated with the Vandalia Till Member of the Glasford Formation (figure 7) and is Illinoian in age. The Vandalia Till lies directly beneath the loess in most of the mapped area. It overlies either till unit D or sand except in TA-5, where it lies directly on shallow bedrock.

The Vandalia Till is a brownish-gray, sandy till containing many thin sand seams, particularly in the upper part. The textural average of the samples is 42 percent sand, 44 percent silt, and 14 percent clay. The clay mineral averages are 11 percent expandables, 68 percent illite, and 21 percent chlorite plus kaolinite.

The Vandalia Till is distinguished from till unit D by its sandy texture, sometimes by color, and to some extent by a higher dolomite content. The natural gamma log configuration of the Vandalia Till usually indicates less radiation than from other tills. In fact, the existence of the Vandalia Till in TA-17 between split-spoon samples is inferred from the gamma log and from stratigraphic probability based on surrounding borings.

In the northern fringe of the mapped area, the Vandalia Till is beneath the Radnor Till Member of the Glasford Formation and/or the Piatt Till Member of the Wedron Formation (figures 7 and 8) of Wisconsinan age. The Vandalia Till is distinguished from the overlying Radnor by its sandier texture, lower illite content, higher expandable content, a change in the vermiculite index (see TA-6), and to some extent by a stronger brownish tint. There is frequently a sand layer between these two tills, as found in TA-6 and in previous studies (Kempton et al., in press).

The Vandalia Till is distinguished from the Piatt Till in the study area by a sandier texture, lower illite content, higher expandable content, and frequently by a paleosol between them.

The Vandalia Till is fairly thin in the study area and is missing in eleven borings where it has been removed by erosion and replaced by the sand and gravel of the aquifer.

The Radnor ice sheet advanced a short distance into the mapped area, depositing the Radnor Till Member of the Glasford Formation (figure 8). There is some evidence that the time interval between deposition of the Vandalia and Radnor Tills was short. In fact, the Radnor ice sheet may have overridden the Vandalia ice before the melting of that ice was complete.

The Radnor Till was encountered during this study only in TA-6. Three Radnor Till samples from this boring have an average texture of 33 percent sand, 47 percent silt, and 20 percent clay. Clay mineral averages are 3 percent expandables, 77 percent illite, and 20 percent chlorite plus kaolinite. The Radnor Till is less sandy than the Vandalia Till; mineralogically, it has a higher illite content and a lower percentage of expandables than either the underlying Vandalia Till or the overlying Piatt Till Member of the Wedron Formation. The vermiculite index of the Radnor Till is also distinct from the Vandalia and Piatt Tills. The Radnor Till is gray rather than the brownish-gray of the Vandalia Till.

The top of the Radnor Till and the base of the Piatt Till are separated in TA-6 by a well-developed paleosol, the Farmdale-Sangamon Soil. The same paleosol was found developed in the top of the Hagarstown Member, beneath the Piatt Till, in TA-3.

The Hagarstown Member, currently assigned to the Glasford Formation, consists of ice-contact deposits associated with Illinoian ice sheets. The Hagarstown is the uppermost member of the Glasford and has been generally restricted to hills and ridges on the Illinoian till plain, frequently referred to as "ridged-drift" (Jacobs and Lineback, 1969; Lineback, 1979). The composition of the Hagarstown varies from clean sand and gravel to till.

Many of the Hagarstown deposits trend in a northeast-southwest direction. The aquifer studied in this report is a Hagarstown deposit forming a nearly continuous ridge of sand and gravel with the characteristic northeast-southwest trend. The sand and gravel were deposited by a meltwater stream which was initially channeled upon or within the Vandalia ice sheet by a large linear ice crevasse. The stream cut a deep, narrow valley, reaching bedrock at some locations. The sand and gravel are probably in contact with the bedrock surface throughout most of the length of the deposit.

Between Taylorville and Macon, the top of the sand and gravel is up to 30 feet higher than the surrounding Illinoian till plain. South of Taylorville, the aquifer lies beneath modern stream valleys. The alignment of the north and south segments of the deposit suggests a common erosional history of the original valley now occupied by the aquifer. The differences in productivity and in geomorphic expression between the two halves suggest a difference in depositional history of the aquifer material. The Vandalia ice sheet must still have existed north of the South Fork of the Sangamon River during deposition, forming valley walls higher than the present land surface, while to the south the ice had probably melted or become very thin by the time deposition occurred. Whether the Radnor ice sheet reached its southern terminus during or after formation of the aquifer has not been established.

After deposition of the tills and associated outwash of the Glasford Formation, a warming trend evolved into a major interglacial stage, the Sangamonian. During this warm stage a well-developed paleosol formed, known as the Sangamon Soil.

As the Sangamonian Stage came to an end, continental ice sheets again pushed southward into Illinois. During the early Wisconsinan glaciation a thin deposit of loess covered the Sangamon Soil in the study area. Before any Wisconsinan ice reached the study area a major glacial retreat occurred, known as the Farmdalian Substage, that allowed further soil development on the land surface. In the study area the Farmdale Soil developed through the thin loess and into the Sangamon Soil. The organic-rich silt portion of the Farmdale Soil is known as the Robein Silt. Carbon-14 dates on the materials from the upper part of the Farmdale-Sangamon Soil found in TA-6 and TA-3 are, respectively, $21,250 \pm 170$ and $20,870 \pm 130$ years-before-present.

Late Wisconsinan ice reached the northeast corner of the mapped area, leaving the very prominent Shelbyville Morainic System to mark the approximate southernmost position of the ice front (figures 8 and 9). The till which composes the Shelbyville moraines in the study area is classified as part of the Wedron Formation and is correlated with the Piatt Till Member. The Fairgrange Till Member (figure 7) was not encountered in the study and may not be present. However, it has been mapped beneath the Piatt Till immediately north of the study area (Lineback, 1979) and is mentioned here because it may be present beneath the Piatt at the northern edge of the study area.

The Piatt Till was encountered in borings TA-3 and TA-6. The textural average of eleven samples, disregarding two anomalous samples, is 30 percent sand, 48 percent silt, and 22 percent clay. Clay mineral averages of twelve samples, with one oxidized sample in TA-6 deleted, are 7 percent expandables, 73 percent illite, and 20 percent chlorite plus kaolinite.

The Piatt Till is a gray till, distinguished from the underlying Radnor Till by a slightly lower illite content and a change in the vermiculite index. The paleosol at the base, found in TA-3 and TA-6, is frequently a good marker bed, as has been previously discussed.

The Henry Formation is outwash associated with Wedron ice sheets, and lies on top of or downslope from exposures of Wedron tills. In the study area, it occurs along the margin of the Shelbyville Morainic System (figure 8).

The Cahokia Alluvium includes all deposits from modern streams, and is found in several valleys in the study area (figure 8). Cahokia deposits were encountered in TA-20, along Brush Creek.

### *Aquifer Description*

Where the Hagarstown deposit is less than 20 feet thick, the grain size usually is finer so that a hydrologic boundary exists. Therefore, the lateral boundaries of the aquifer for practical purposes are drawn to coincide approximately with the 20-foot thickness line (figure 9), even though the geologic unit is wider.

The southern part of the aquifer, which extends from the South Fork of the Sangamon River to Morrisonville, is generally thinner and less consistent in grain size than the northern part. It is topographically expressed as shallow valleys occupied by Brush Creek, Bear Creek, and a tributary of West Fork Shoal Creek. The till plain of the southern part of the study area is characterized by parallel and perpendicular valleys, commonly with right-angle bends. The pattern is suggestive of structural control from within the glacial ice. Surface drainage along the south part of the aquifer is into the overlying creeks which flow northeast to the South Fork of the Sangamon, except for some drainage into the West Fork of Shoal Creek, which flows southwest. Principal recharge is through the Cahokia Alluvium of the modern streams directly over the aquifer.

Data for the southern portion of the aquifer are much more limited than those for the northern portion. Information available is from electrical earth resistivity profiles, municipal water wells, and boring TA-20. The data are insufficient for detailed mapping of the southern part of the aquifer.

The northern part of the aquifer generally lies beneath a nearly continuous ridge extending from near the town of Macon to the South Fork of the Sangamon River at Taylorville. The ridge forms a local drainage divide on the Illinoian till plain. Southeast of the ridge, runoff is carried southwest in the Flat Branch valley. Drainage northwest of the ridge is to the north and west by small streams. Recharge to the aquifer is primarily through the thin loess cap directly over the aquifer.

The aquifer thickness map (figure 9) was made from data derived from borings made for this study, from records of previously drilled wells in and near the aquifer, and from the interpretation of numerous surface electrical resistivity profiles made specifically for this study and over the past 30 years by the Geological Survey. Even with this information, much extrapolation was necessary over areas of limited data. Where data are adequate, a strong relationship can be seen between the configuration of the aquifer and the land surface topography. Therefore, in areas where extrapolation of aquifer thickness was necessary, a strong reliance was placed on that relationship.

Prior to this study, there was no evidence that the aquifer extended north of the margin of the Shelbyville Morainic System near Macon. TA-3 was drilled where the projected continuation of the aquifer was expected if it existed beneath the Wedron Formation. When the aquifer was found at this site, the likelihood that the aquifer might be hydrogeologically linked with the sands and gravels closer to Decatur was considered. TA-6 was drilled as a further test of this hypothesis, but the aquifer was not encountered. The probability of a continued northward extension of the aquifer is strong (see Kempton et al., in press), but the cover of thick Wedron Formation till will make it more difficult to trace. Surface resistivity work near TA-3 suggests that the aquifer may be much nar-